SUSTAINABLE WATER DEVELOPMENT WITH RENEWABLES

Village Power 2000

Robert Foster
Southwest Technology Development Institute
College of Engineering
New Mexico State University

http://www.nmsu.edu/~tdi

Requirements for Successful Renewables Development

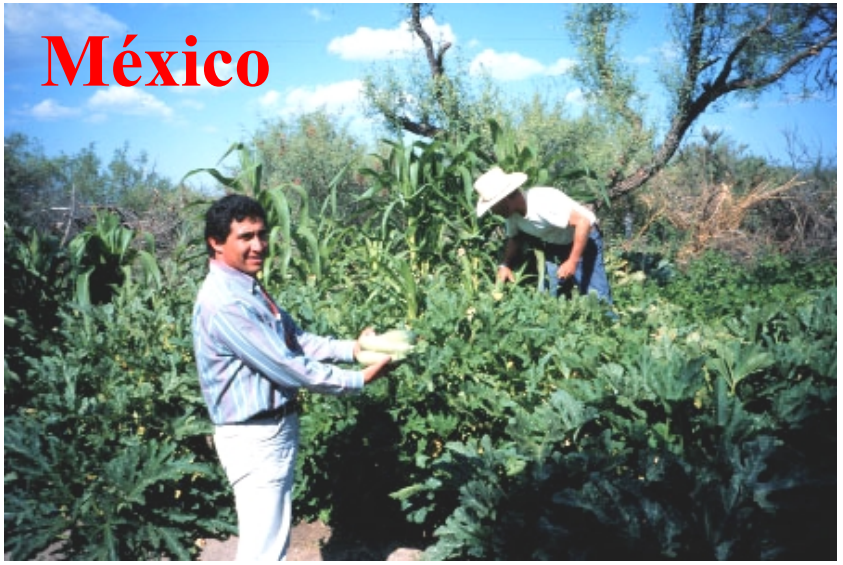
- Strategic Planning
- Capacity Building
  - Local Training
  - Long-Term Technical Support
- Cultural Acceptance
  - Local Buy-In
  - Grassroots Approach
  - Solid Partnerships
- Sustainable Markets
  - Mainstream Industry
  - Proven Technologies
  - Safe & Quality Installations
  - Financing
- Evaluation
  - Long-Term Monitoring
  - Evaluate Results
  - Conduct Follow-up

Water Pumping

- Evalute options (e.g, gravity feed)
- PV Water Pumping
  - Domestic water supply
  - Livestock water supply
  - Small scale Irrigation
- Wind Water Pumping
  - Domestic water supply
  - Livestock water supply
  - Irrigation

Irrigation

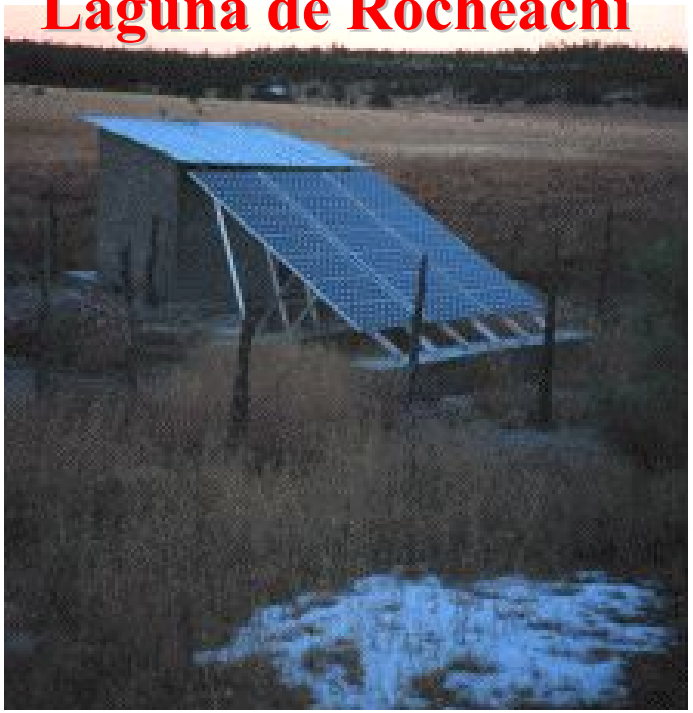
- Conserve Water First (e.g., drip irrigation)
- PV for small scale (< 1 Ha)
- Wind for medium/large scale



Indigenous WP Projects

Guachochi

Laguna de Rocheachi



Life-Cycle Cost Analysis

Case Study-El Jeromín, Chihuahua

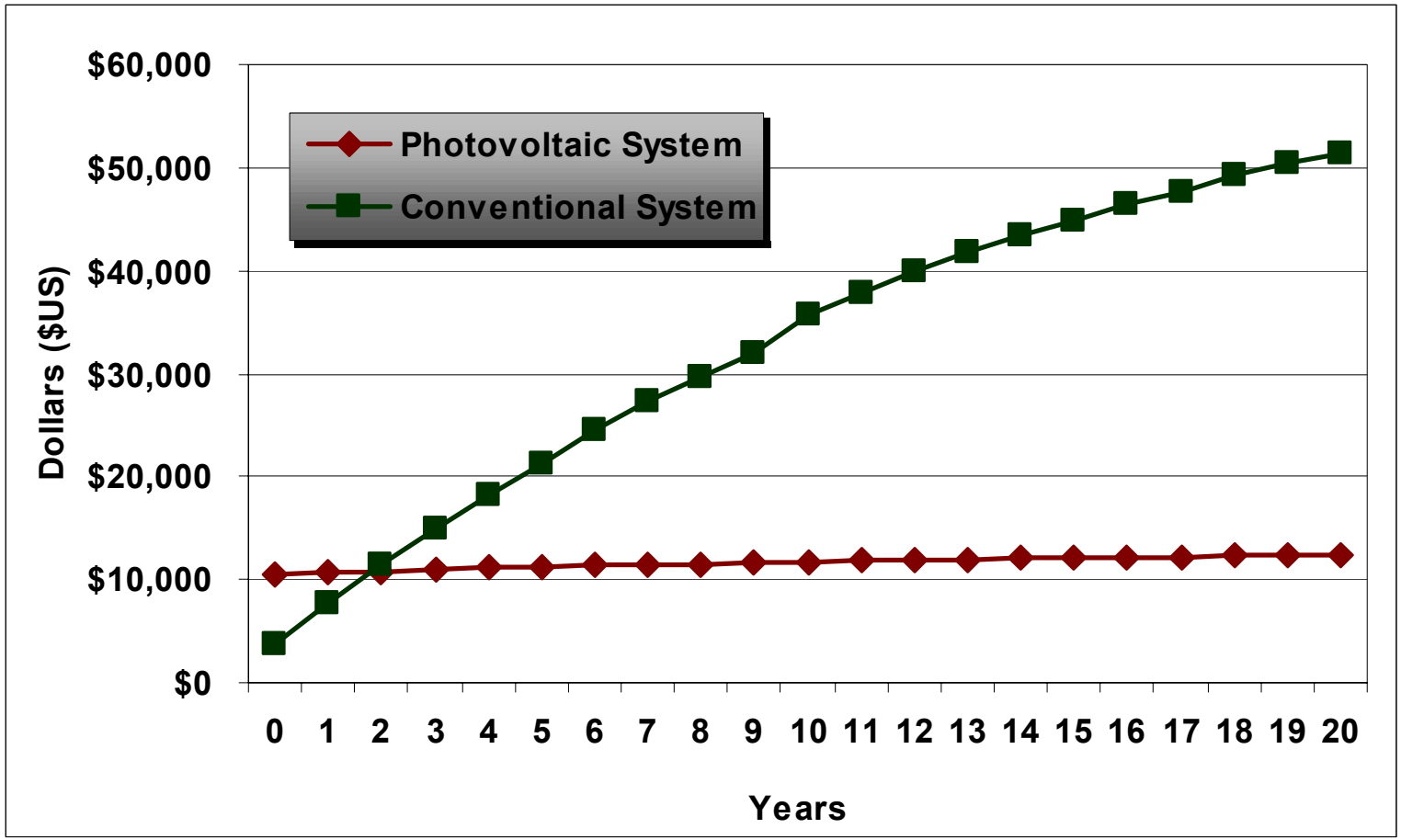
AFTER

BEFORE

- 848 Wp PV system installed in March 1997 with no maintenance since
  - 16 Solarex VRX-53 modules
  - Grundfos SP3A-10 pump
  - SA-1500 controller
- Cattle Ranch with desert vegetation
- 15,000 liters of water per day

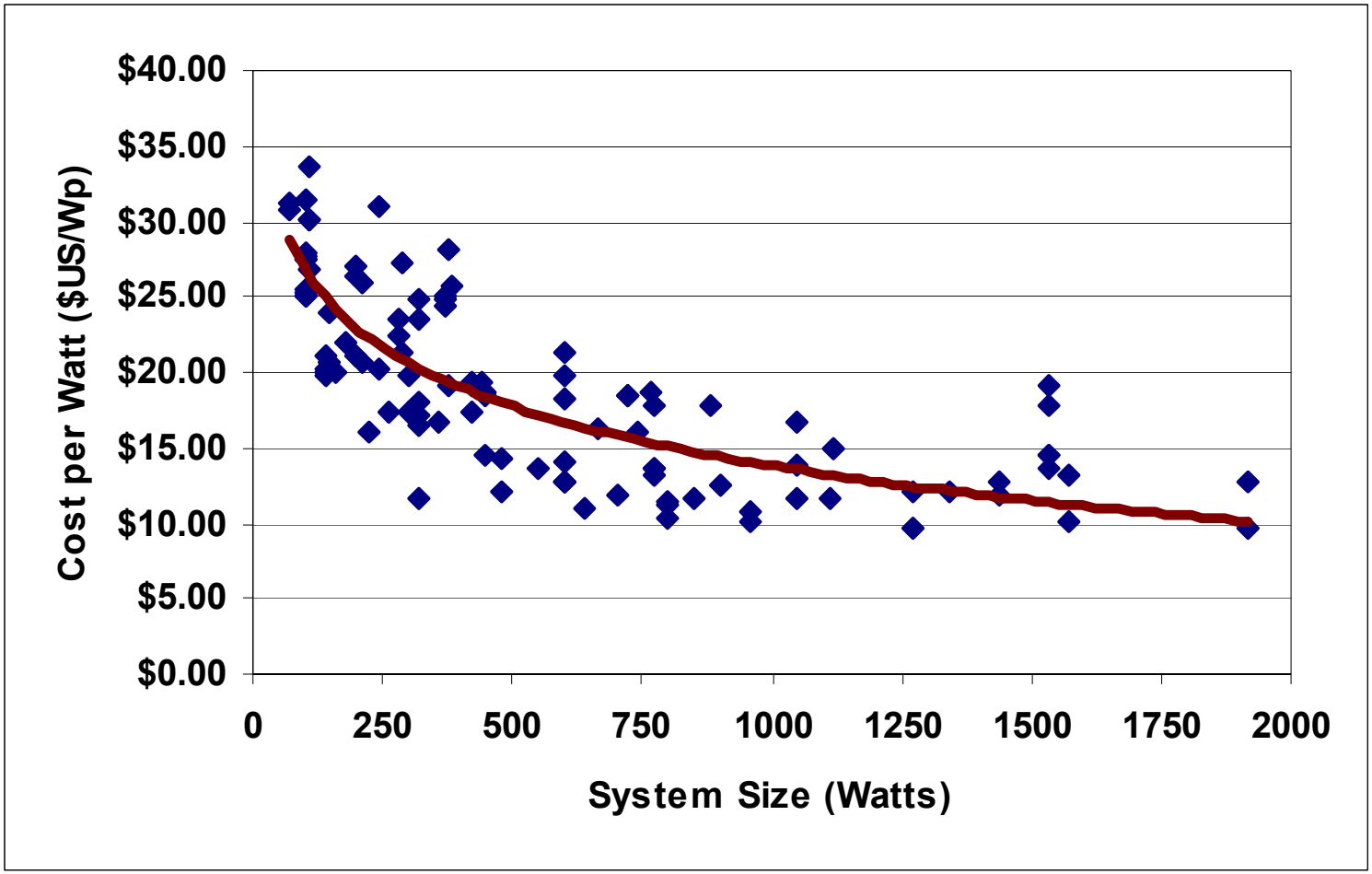
Case Study - El Jeromín, Chihuahua

Results



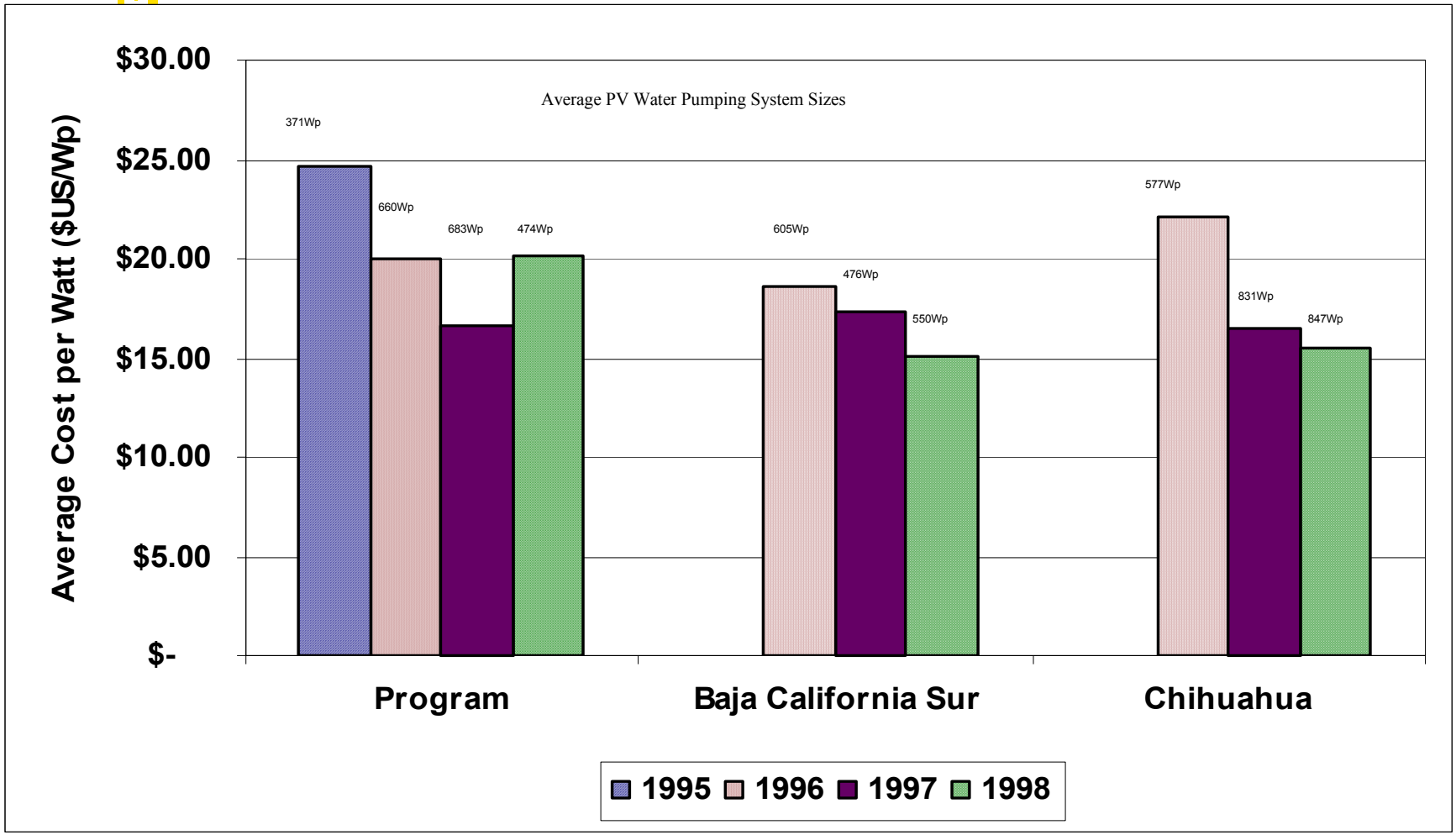
- **After 2.5 years, the PV system represents a lower overall expense to the user**

PV Water Pumping
Mexico: Cost per Watt Vs. System Size



PV Water Pumpers for remote non-electrified sites are in general competitive when under 2 kW in size

Mexico program database shows that prices decrease as markets mature



Reverse Osmosis

- Uses osmotic pressure to remove impurities
- Pros
  - Produces high quality water
  - Removes salts and minerals
  - Removes micro-organisms
- Cons
  - High energy inputs
  - High maintenance (membrane replacements)
  - No residual

Water Purification

- Reverse Osmosis
- Ultraviolet
- Mixed Oxidants
- Distillation

UV

- Uses ultaviolet light to disinfect water
- Pros
  - Eliminates micro-organisms without chemical addition
- Cons
  - No residual
  - No salts and minerals removed
  - Should replace UV bulb every year
  - Less effective in the presence of suspended solids

Mixed Oxidants

- Electrodialysis of NaCl to produce oxidants (Ozone, Cl, ClO_2)
- Pros
  - Strong disinfecting solution
  - Provides residual disinfection capacity
- Cons
  - Does not remove dissolved minerals
  - Significant operator interface required
  - High energy inputs
  - Requires pure salt to operate

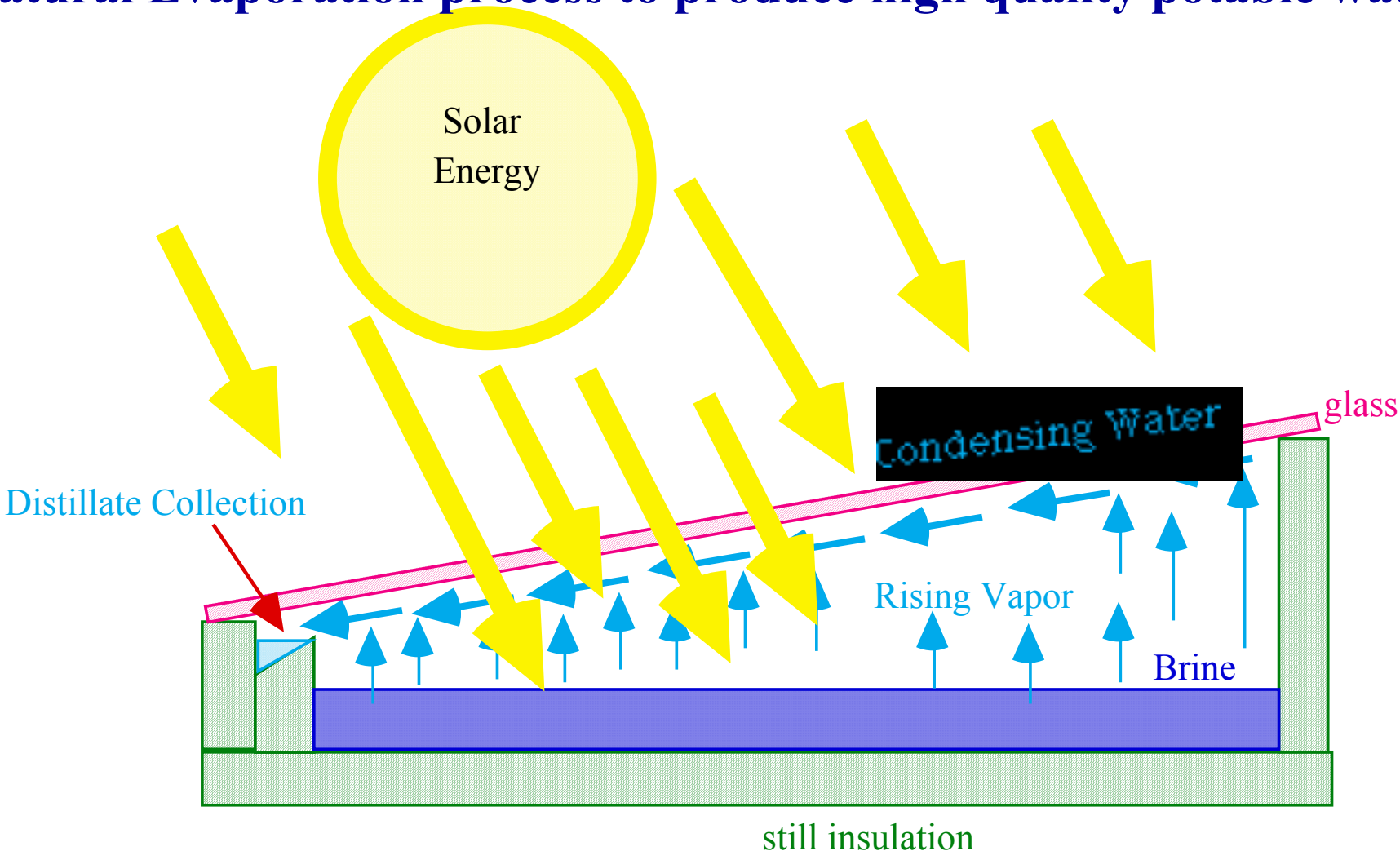
Distillation

- Distillation is effective in removing
  - Salts/Minerals (e.g., Na, Ca, As, Fl, Fe, Mn)
  - Bacteria (e.g., E. Coli, Cholera, Botulinus)
  - Parasites (e.g., Giardia, Cryptosporidium)
  -

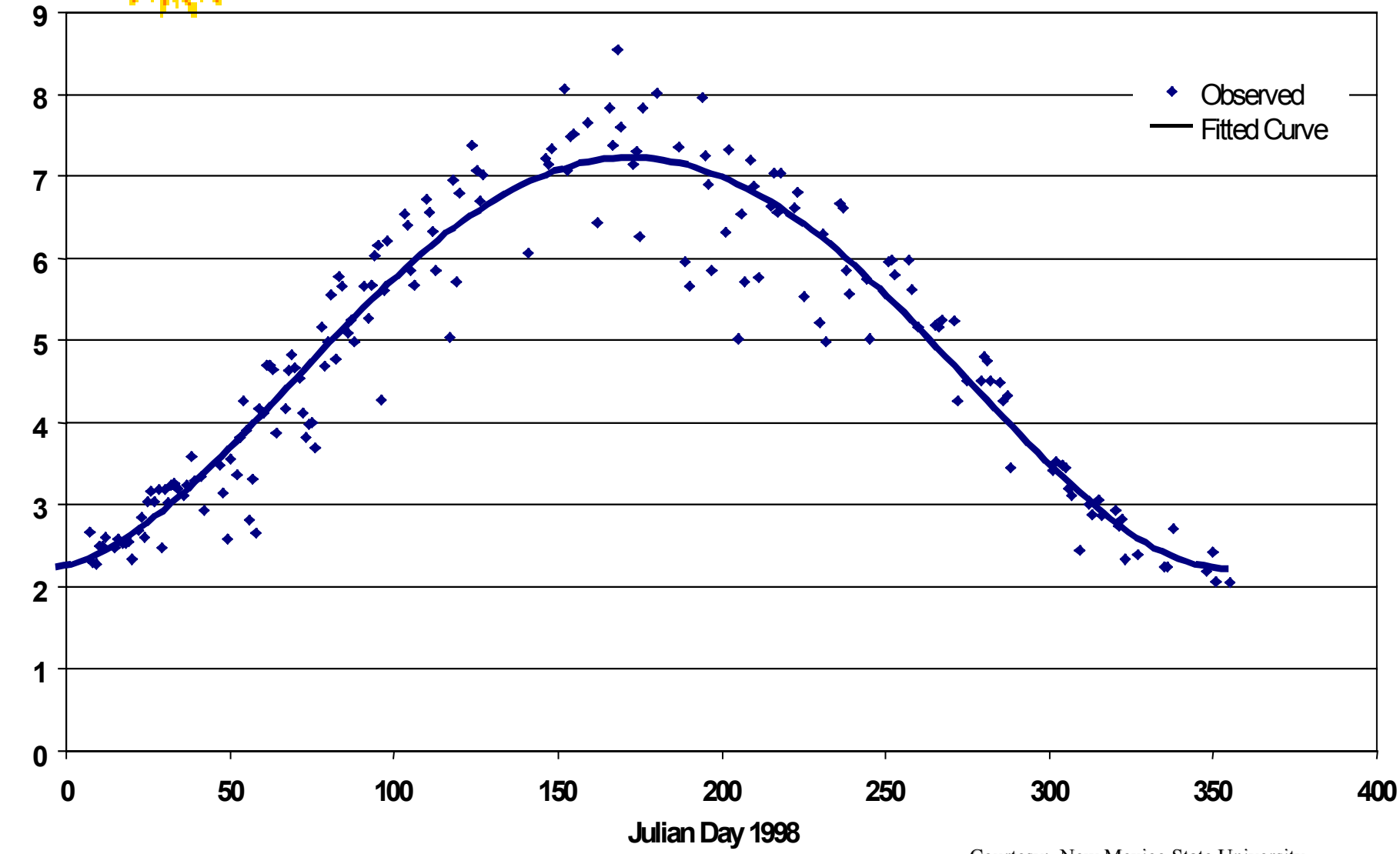
- Pros
  - High Water Quality
  - Solar Energy Easily Used
  - No Moving Parts
  - Long Life
  - Simple to Operate
  - Simple to Maintain
  - Low Life Cycle Cost
  - Can be Automated
- Cons
  - Small Product Volume
  - Potential VOC Carryover if no carbon filter used
  - No Residual

Solar Still Operation

Natural Evaporation process to produce high quality potable water

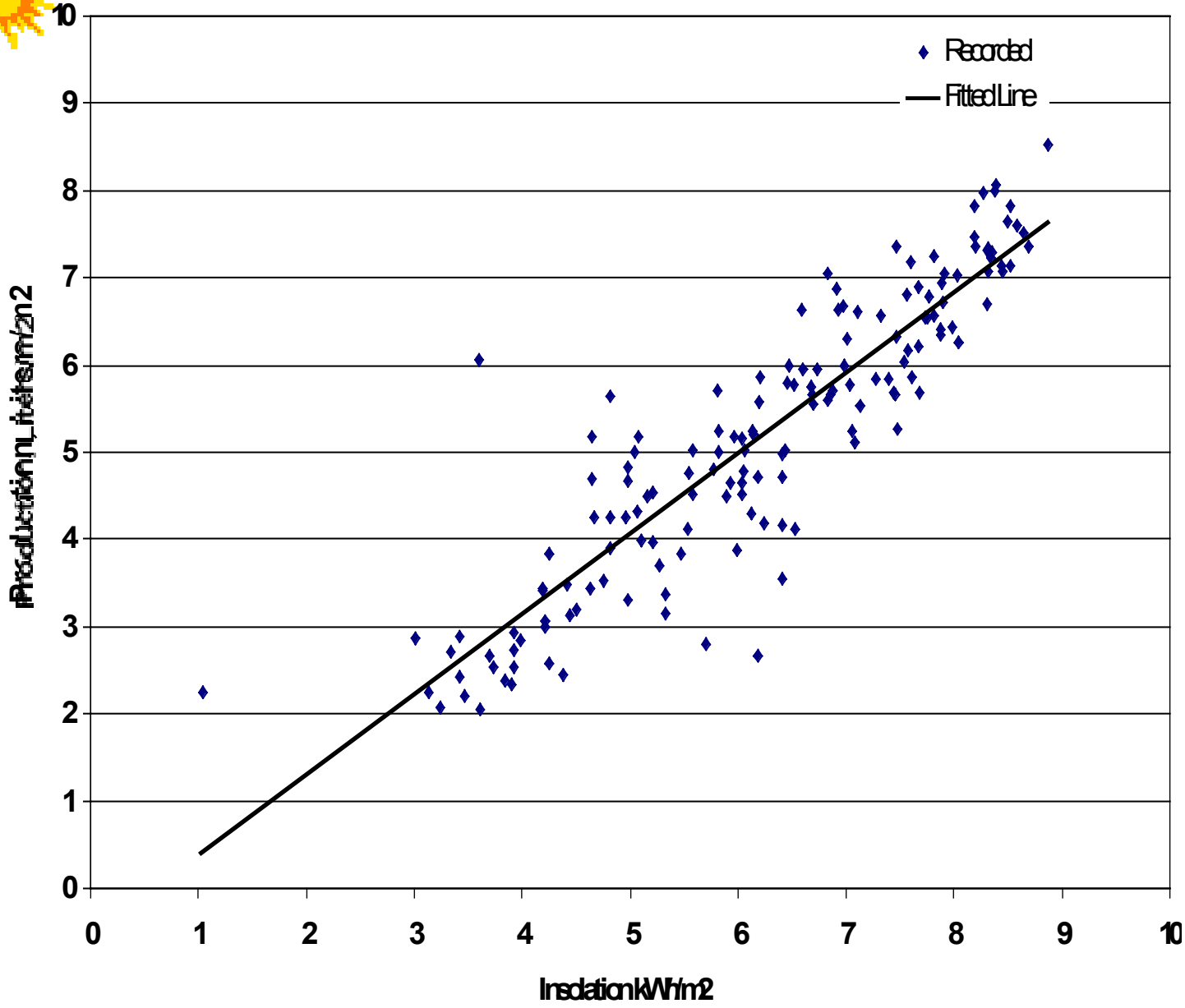


Annual Solar Still Production
Las Cruces, New Mexico



Courtesy: New Mexico State University

Water Production Compared to Solar Insolation



Water Quality Results

Sandia National Laboratories

Sample Type	13‰ salinity feedwater	Solar Distilled water (13‰ case)	16‰ salinity feedwater	Solar Distilled water (16‰ case)
Calcium (total)	340	1.5	371	<0.10
Iron (total)	0.27	<0.05	0.48	<0.06
Magnesium (total)	2.1	2.1	<0.005	<0.005
Manganese (total)	0.04	<0.02	0.07	<0.02
Ammonia as N	<0.1	0.1	<0.1	<0.1
Chloride	19000	<1.0	25000	2.6
Fixed Solids	32000	<1.0	41000	31
Nitrate as NO_3	34	0.1	26	<0.1
Nitrate as NO_2	0.013	<0.01	0.02	<0.01
TDS	36000	<1.0	48000	<1.0
Volatiles & Organic	4200	<1.0	6000	13

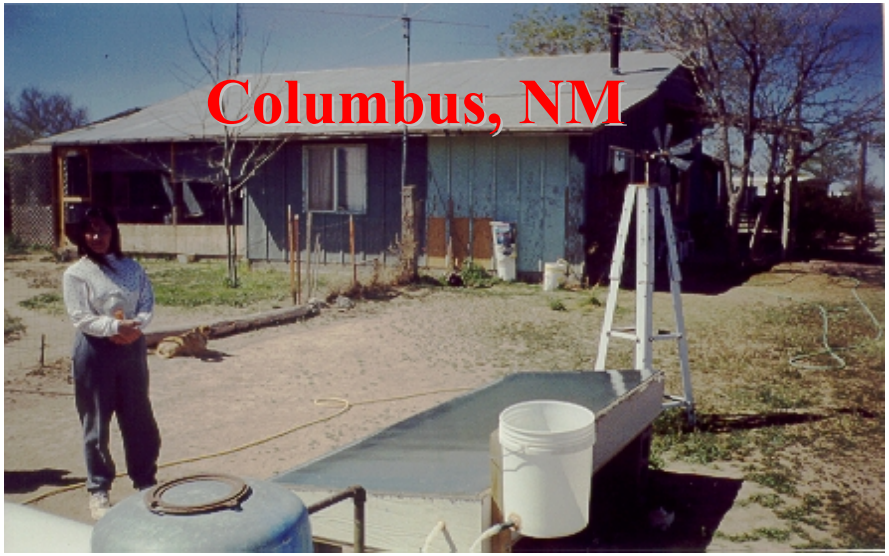
Water Quality Test Results

New Mexico State University

Field Still Ref. No.	Conductivity, µS/cm	Hardness, mg/L as $CaCO_3$	Fluoride, mg/L	pH
# 20 Input	1190	260	6.2	7.9
# 20 Output	4.8	4	0.1	9.2
# 22 Input	1180	250	8.2	7.4
# 22 Output	1.8	0	0.10	9.1
# 29 Input	1200	250	6.0	8.1
# 29 Output	5.8	8	0	8.8
# 30 Input	2390	480	n/a	6.8
# 30 Output	4	4	n/a	9.4

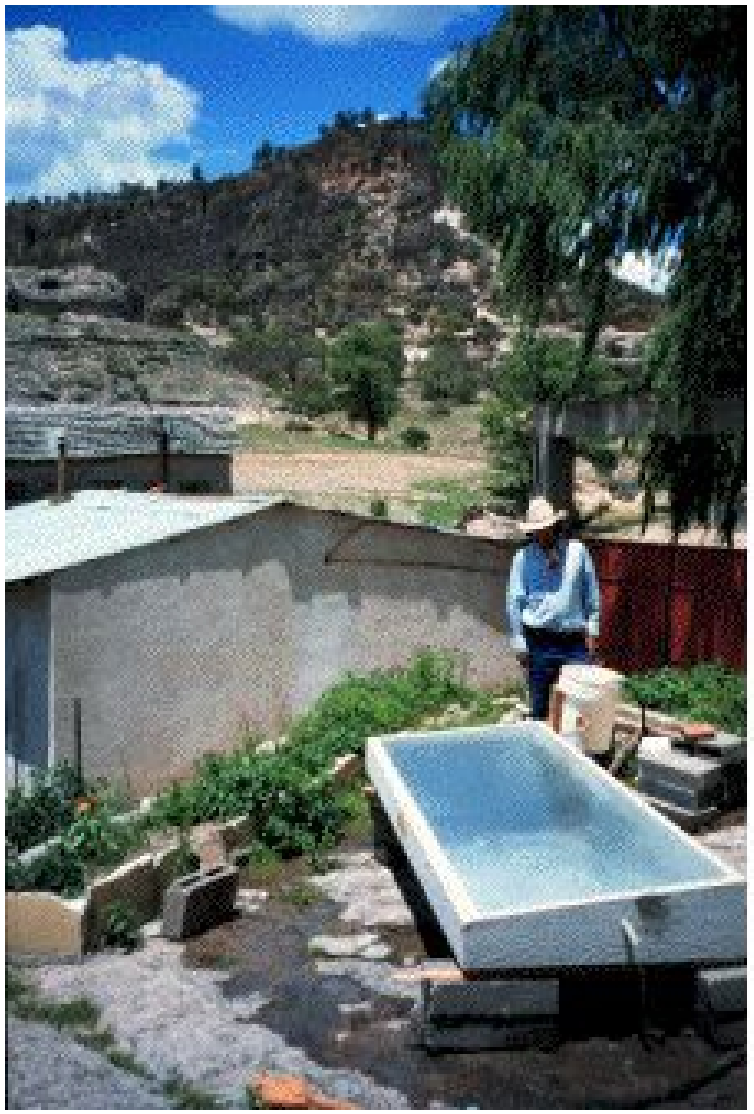
Sample	Volume Tested ml	Total Organisms per liter
Supply	50	16,000
Distillate	1,000	4 (No *E. coli*)
E. coli Seed	--	2,900,000,000
Distillate	750	11 (No *E. coli*)
E. coli Seed	--	7,500,000,000
Distillate	1,000	18 (No *E. coli*)
Supply	10	24,000
Distillate	1,000	13 (No *E. coli*)
Supply	1	12,000
Distillate	1,000	6 (No *E. coli*)

U.S. Applications in the Southwest



Solar Distillation in Chihuahua, Mexico

Cd. Juárez Orphanage



Indigenous Tarahumara Rural Health Clinic, Norogachi

Anapra Colonia, Cd. Juárez, Mexico

The Valdez family used to buy water at 13 pesos every 3 days (~US$175/year).
They believe that the still water tastes better than store-bought water and now they have more water. Simple still payback is 3.7 years for them.

www.epsea.org

Technology Cost Comparison: Amortization 7% for 10 years

Method($ Ê	Ini ital Cost per month ($)	Ini ital Cost per gallon ($)	Replacement Parts per gallon ($)	Power Cost per gallon ($)	Tota lCost Per ga lon ($)
R.O. 4 stgs .	9. 2	0. 123	0. 10		0. 2
R.O. 4 stgs .	8. 1	0. 16	0. 86		0. 2
R.O. 3 stgs .	6. 3	0. 90	0. 94		0. 8
Dist -E ec.	5. 6	0. 076	0	0. 3	0. 5
Dist -E ect .	16 22	0. 216	0	0. 3	0. 5
Dist -E ect .	20 89	0. 279	0	0. 3	0. 6
Solar sti l (1.7 m^2)	8. 2	0. 10	0		0. 1
Solar sti l (many)	5. 4	0. 074	0		0. 0
Bott ed Water	0. 0	0. 00	0	0	0. 5

Clean Water Technology Effectiveness Comparison

Pollutant	Purification		Crossover		Disinfection				
	Carbon Filter	Deionization	RO	Distillation	Boiling	Chlorination	UV*	Ozonation	Mixed Ox
Arsenic									
Bacteria									
Cadmium									
Calcium									
Chlorides									
Chlorine			*	*					
Crypto									
Detergents									
Fluoride									
Iron									
Lead									
Mercury									
Nitrate									
Organics			*	*					
Pesticides			*	*					
Sediement									
Sodium/Salt									
Viruses									
Residual									

Ineffective or no reduction

Significant reduction

Complete reduction

* carbon filtered required

Successful Renewables Development

- **Work within Cultural Norms**
  - **Acceptability**
  - **Useful**
- **Use Appropriate Technology**
  - **Good Quality**
  - **Reliable**
  - **Low Maintenance**
  - **Simple is Best**
- **Build Local Capacity**
  - **Training**
  - **Infrastructure**